INTRODUCTORY LECTURE

BY

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WITH

A SHORT ACCOUNT OF THE

LEWIS BROOKS' MUSEUM

OF NATURAL HISTORY.

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Dr. J. F. Harrison,
University of Virginia, Va

THE LEWIS BROOKS MUSEUM

AND THE

CORCORAN SCHOOL OF NATURAL HISTORY.

The University of Virginia owes its present excellent facilities for the teaching of Natural History mainly to the enlightened liberality of two men, on whom she could make no claim in virtue of their being either her alumni, or natives of Virginia.

In 1876, Mr. Lewis Brooks, of Rochester, New York, through Prof. Henry A. Ward of the same city, acting as his agent, offered to establish at the University a complete and costly Museum of Natural History, provided that other friends of the University would raise the sum of $12,000 to defray the expense of purchasing the necessary cases, and to pay for the mounting, transportation, &c.

Mr. Brooks, in making this offer, was influenced only by his desire to promote the cause of education at an institution which was known to him only as being especially representative of the South, and as having been founded by Mr. Jefferson, of whom he was a devoted admirer.

In making this offer Mr. Brooks was also entirely disinterested, for he directed that his name should be withheld, and up to the time of his death no member of the Faculty, or Board of Visitors even, was in possession of it, except the Rector, to whom, as the representative of the University, it was necessarily made known.

The Board of Trustees of the Miller Agricultural Department of the University pledged $10,000 of the amount required in Mr. Brooks' condition, and the remaining $2,000 were supplied by Prof. Wm. B. Rogers and alumni of the University.

Thereupon, under pledge of secrecy, the following letter was addressed to the Hon. A. H. H. Stuart, Rector of the University :

ROCHESTER, April 14th, 1876.

To the Rector and Visitors of the University of Virginia:

Gentlemen,—

Prof. Henry A. Ward, of this city, will deliver to you herewith forty-five bonds of the Chicago, Burlington and Quincy Railroad Company of one thousand dollars each—$45,000.

This sum being deemed by Prof. Ward sufficient to enable you to provide a suitable building for a Cabinet of Natural Science, (with the exception of Botany,) and to procure through him, on terms which will be mutually satisfactory, the necessary material for such Cabinet, which in extent, and all respects, will be well adapted to the purpose of instruction in this department of education in the University of Virginia, I respectfully tender for your acceptance the bonds above mentioned; the avails of twenty-five of them to be devoted to the procurement of the material for such Cabinet, and the remaining twenty to the erection of a suitable building. I am, gentleman,

Very respectfully yours, LEWIS BROOKS.

The proceeds of the bonds amounted to $50,000. To this sum Mr. Brooks afterwards added nearly $20,000 for the extension of the building, authorizing among other things, the addition of a Botanical Hall.

The building was completed in July, 1877, and before the collection of specimens had been fully arranged and placed in position, the death of Mr. Brooks was announced. This happened before any provision had been made for the procuring of the Botanical specimens to occupy the Botanical Hall, which Mr. Brooks had authorized to be added to the building. His heirs, however, in order to carry out fully his plan for the Museum, generously made a donation to purchase the specimens for the Botanical Hall, and thus the Museum was finally made complete.

By the establishment of this splendidly-furnished Museum, the University was put in possession of a most admirable instrument for illustrating the principles of Natural History, but as she was situated at the death of Mr. Brooks,

she could not reap the full benefit of his generous gift. To fully utilize the large collections contained in the new Museum, she needed a chair of Natural History, which should be occupied solely with the teaching of that subject, and this she did not possess.

At this juncture Mr. W. W. Corcoran, of Washington, D. C., came to the relief of the University by a most liberal and judicious gift. He donated to her the sum of $50,000, for the purpose of endowing a professorship of Natural History. This was all the more highly appreciated, as this gentleman had already proved himself to be a generous and disinterested friend of the institution, by having made it most liberal gifts on several occasions.

The gift of Mr. Corcoran enabled the Board of Visitors to complete the Department of Natural History by the establishment of a chair of Geology and Natural History, which was subsequently filled by the election of Prof. Wm. M. Fontaine.

THE LEWIS BROOKS MUSEUM.

The collections of the Museum were made by Professor Henry A. Ward, of Rochester, N. Y., who is eminently fitted for this duty, since he is both an experienced teacher of Natural History, and has unsurpassed facilities for the collection of Natural History objects. It must be borne in mind that the chief object had in view in the making of the collections was their use as teaching instruments. It is easy to see that large, attractive and costly collections may be made which would have little value in illustrating the principles of science. This has been studiously avoided in making the collections for the Lewis Brooks Museum, and in consequence of this, it is hardly surpassed any where as an instrument for the illustration of Natural History. The specimens are both selected and arranged for the illustration in their proper order of the different portions of the various branches of Natural History. For want of such

arrangement, most of the large public museums are almost worthless as aids to the teacher of science.

THE BUILDING.

The building is both handsome and substantial, forming a decided ornament to the University grounds. It contains two principal halls, a lower and an upper. The lower hall contains on the floor the Geological collections, and in galleries running around the entire hall, the Mineralogical collections. The upper hall contains in its main portion the Zoölogical collections, while attached to it on the same floor is the Botanical hall, in which the specimens are not not yet mounted, though most of them are on hand. A lecture-room and laboratories are also present in the building.

THE COLLECTIONS.

In speaking of the collections no attempt will be made to give a catalogue of them. Only a few objects will be mentioned, in the order of arrangement, so that the reader may form some idea of the scope and character of the different groups.

CABINET OF MINERALOGY.

The Cabinet of Mineralogy contains in the aggregate about 3,000 carefully selected and handsome specimens, which are classified in two divisions. The first division illustrates the structure and physical properties of minerals. The second is the systematic collection, in which the mineral species are arranged in classes.

STRUCTURAL AND PHYSICAL DIVISION.

The specimens in this division are chosen with a view to the illustration of the various natural properties of minerals, as shown in their external features and internal structure.

I.—Structural Series.

Crystallography.—Crystallography, or the external forms of crystals, is illustrated in the collection, both by

natural crystals, and by artificial models. The six systems of crystals are illustrated by glass models, showing the forms of the crystals and their axes. Numerous wooden colored models exemplify all the most important, simple and derived forms of crystals in each system.

Besides these, *Twin crystals*, *Hemitropes* and *Pseudomorphs* are fully illustrated by numerous models and natural forms.

Structure, as developed in crystalline aggregates, from imperfect crystal forms, is also fully shown in many illustrative specimens.

II.—PHYSICAL SERIES.

Several hundred specimens are arranged in series, so as to exhibit the character of minerals depending upon *light*, *cohesion*, &c., &c. *Series* 1 illustrates properties depending upon light, and contains many specimens exhibiting the different kinds of *lustre*, *color*, and *shades of color*, *play of colors*, *opalescence*, *iridescence*, *tarnish*, *pleochroism*, *&c.*

The degree of transparency, or *diaphaneity*, of minerals, is also fully displayed in this series. *Series* 2 illustrates by many specimens the qualities due to differences of cohesion, as *hardness*, *brittleness*, *malleability*, *elasticity*, *flexibility*, &c., &c., with also the different kinds of *fracture*, such as *even*, *conchoidal*, *hackly*, &c.

The specimens composing the above mentioned series present a visible and tangible glossary of all the terms used in the description of the physical properties of minerals. A complete and well chosen suite of minerals, illustrating the physical properties of minerals, is of the highest importance in the study of Mineralogy, for if the student makes himself thoroughly acquainted with these properties, his labor in the determination of minerals will be greatly lightened, and in the case of many minerals he may, by such knowledge alone, determine their character.

THE SYSTEMATIC COLLECTION OF MINERALS.

In this collection are placed the different species of minerals, so arranged as to exhibit their relations to each other, as well as their distinguishing characteristics. The cabinet contains about three-fourths of the species recognized. The most important are represented, each by several specimens, including both the crystallized and amorphous condition of the mineral, and illustrating the varieties, if such exist. They are, in the main, from European and American localities, the mining districts of Cornwall, Saxony and Hungary having furnished the choicest masses of ore and the most brilliant crystals. Each specimen is mounted on a handsome black walnut block, which has a printed label with the name of the mineral and the locality. The detached crystals are mounted on upright brass holders, which have on their pedestal the name of the mineral and the form of the crystal.

The systematic series is grouped into the following classes, each of which contain numerous species, illustrated by many specimens :

Class 1.—*Carbon and Boron Compounds.*—This includes the diamond, the varieties of coal, graphite, &c.

Class 2.—*Sulphur and Selenium.*—Contains native sulphur and sulphur with selenium.

Class 3.—*Haloid Minerals.*—This class includes common salt, nitre, polyhalite, borax, strontianite, the many varieties of gypsum and of calcite, with magnesite, dolomite, fluorite, the varieties of sapphire, and many other minerals.

Class 4.—*Earthy Minerals.*—This includes the numeous varieties of quartz, opal, serpentine, pyroxene, hornblende, the feldspars, tourmaline, &c., and a great number of rare minerals.

Class 5.—*Metals and Metallic Ores.*—This class includes a great number of the compounds of tin, titanium, iron,

copper, lead, silver, gold, nickel, cobalt, bismuth, antimony, arsenic, &c., &c., and contains many rare minerals.

Class 6.—*Resins.*—This contains such minerals as amber, bitumen, mellite, &c.

Besides the specimens of the actual minerals, the collection contains *fac similes* in glass of all the notable Crown Diamonds. It also contains representations in colored glass of the natural crystal forms of the various precious stones, the glass imitations being colored with the proper color of the minerals imitated.

Many of the mineral species in the collection are accompanied by wooden models of the characteristic crystal forms in which the species crystalizes. This is a most useful feature. The collection also contains *fac similes* of the largest nuggets of gold which have been found in various countries.

CABINET OF GEOLOGY.

This department is divided into I. *Geology Proper*, and II. *Paleontology*.

DIVISION I.—GEOLOGY PROPER.

The specimens, about 2,000 in number, illustrating this division, are separated into four sections, as follows :

Section I.—Lithology.—In this collection all the known kinds of rocks are represented by about 600 specimens. The classification is, to a very considerable extent, that of the late Professor Cordier, of Paris, and the one followed in the arrangement of the Rock-Collections of the Garden of Plants. This is, however, much modified to accord with more recent investigations in the science in France and Germany. It is based upon both mineral composition and origin, or form of aggregation, without reference to geological age. The smaller specimens are dressed to a uniform size, and each specimen is mounted upon a separate block, having a printed label supported by a brass holder.

Class 1.—*Granitoid Rocks.*—This is a class of ternary and binary associations of various minerals, commonly of crystalline structure, and including feldspar as a dominant or distinctive element. It contains specimens of granite, gneiss, syenitic gneiss, &c., &c. In this are included the porphyries, as they contain a base of feldspar.

Class 2.—*Trachytic and Basaltic Rocks.*—In this class we find specimens illustrating trachyte, domite, phonolite, basalt, dolerite, melaphyre, &c.

Class 3.—*Volcanic Rocks.*—In this class are arranged the various masses, compact and friable, which owe their origin to volcanic eruptions of modern date. It includes lava from various volcanoes, obsidian, pumice, perlite, scoria, &c.

Class 4.—*Serpentine Rocks.*—In this class are placed serpentine proper and allied rocks, in which occur diallage, and feldspar. Serpentine is illustrated by many beautiful specimens, and we find in addition ophite, hypersthenite, eclogite, &c.

Class 5.—*Amphibolic Rocks.*—This includes hornblende (massive), diorite, &c.

Class 6.—*Slates and Schists.*—The rocks grouped in this class are chiefly metamorphic and laminated. The class includes mica slate, hornblende slate, clay slate, chlorite slate, mica schist, talcose schist, &c., &c.

Class 7.—*Quartz Rocks*—This class contains rocks of both igneous and aqueous origin, in which quartz abounds. We find illustrated in it quartzite, chert, arkose, sinter, &c.

Class 8.—*Limestone Rocks.*—This includes the rocks in which lime abounds. In it are contained numerous specimens of compact limestone, crystalline do., dolomite do. Polished specimens of marble, encrinal limestone, coralline do., lithographic do., chalk, &c., &c.

Class 9.—*Conglomerates and Sandstones.*—These are all debris of other rocks in larger or smaller fragments, cemented by calcareous, siliceous, or ferruginous matter. In

this series we find illustrated the various forms of sandstone, conglomerate, grit, &c.

Class 10.—*Argillaceous Rocks.*—The clays, marls, &c., which compose this class, may be considered as the more finely comminuted states of the preceding class.

We find illustrated here common clays, porcelain clay, loess, tripoli, &c.

Class 11.—*Carbonaceous Rocks.*—In this final class is placed a group of substances chiefly of vegetable origin, which are more or less carbonized. In this class the various coals, lignites, jet, peat, &c., are illustrated, with bituminous slate, &c.

Section II.—*Metallurgy.*—This section consists of a series of ores composed of about 300 specimens. They give a full illustration of the ores of the metals most used in the arts.

Class 1.—*Ores of Iron.*—This class contains specimens of magnetic and specular ore from various localities, as well as chromic iron, spathic iron, hematite, &c., &c.

Class 2.—*Ores of Manganese.*—This class contains pyrolusite, wad, &c., &c., from American and European localities.

Class 3.—*Ores of Copper.*—This contains native copper, oxides of copper, sulphides of do., &c., &c., from Lake Superior, Brazil, Cornwall, Siberia, Saxony, Australia, &c.

Class 4.—*Ores of Lead.*—This class contains galena, the sulphate, phosphate and carbonate of lead, and other ores from many localities in Europe and America.

Class 5.—*Ores of Tin.*—This contains the ores of tin from Cornwall, Saxony, &c.

Class 6.—*Ores of Zinc.*—This class contains the various ores of zinc from New Jersey, England, Saxony, Siberia, &c.

Class 7.—*Ores of Mercury.*—This contains cinnabar from California, Spain, Austria, &c.

Class 8.—*Ores of Silver.*—This class contains specimens of native silver, horn silver, and the various sulphides containing silver, from numerous localities.

Section III.—*Stratigraphical Geology.*—The rocks that characterize the various stratified formations, fossiliferous or not, are here arranged in chronological order. In the representation of the several fossiliferous beds, some of the specimens exhibit the more common and characteristic forms of animal and vegetable life. About 600 specimens are here included, and about one-half of them are selected to give a comprehensive view of the lithological peculiarities of the rocks of various formations of the Old and New Worlds.

The remainder of the section consists of a few local or geographical series of rocks, which represent to a certain extent the geology of some remarkable regions of varied geological constitution.

Series 1.—This consists of about 100 specimens, and represents the metamorphic strata of the region around Mt. Blanc.

Series 2.—Contains about 200 specimens, and represents the Paleozoic rocks of the New York system.

Series 3.—Contains 100 specimens, and represents the peculiar formation of the Paris Basin, with its alternating salt and fresh-water deposits.

Series 4.—Represents by about 100 specimens the volcanic rocks of Mt. Vesuvius.

Series 5.—Is composed of the numerous and diversified rocks that form the volcanic region of Central France.

Series 6.—Represents by a suite of about 100 specimens the typical rocks of Saxony.

Section 4.—*Phenominal Geology.*—The specimens of this section, about 500 in number, illustrate many interesting points in dynamical and physical geology, and many of the phenomena of rock formation and modification under the action of physical forces.

The following enumeration includes all the more important of the phenomena illustrated:

(1.) *Columnar structure*, shown in Basalt from various localities; (2.) *Alteration of sedimentary rocks by igneous dykes;* (3.) *Veins of segregation, veins of aggregation and infiltration, &c.;* (4.) *Jointed structure:* (5.) *Slaty cleavage;* (6) *Polished surfaces or slicken sides;* (7.) *Contorted and folded laminae;* (8.) *Concretions.* The series of concretions is very full, the material being mainly *clay*, *limestone* and *pyrite;* (9.) *Glacial markings;* (10.) *Ripple marks and rain drop impressions;* (11.) *Flexible sandstone;* (12.) *Geodes*, empty, nucleated and lined with crystals; (12.) *Cone in cone, dendrites, &c.*, the latter very numerous and handsome; (14.) *Volcanic bombs, scoria, amydaloids, &c.;* (15.) *Stalactites, stalagmites, &c.;* (16.) *Meteoric stones* from the United States and Mexico, and with these *fac similes* of 20 celebrated meteorites.

This series is completed by an important series of geological models and maps. (*a.*) *A relief map* (5 feet square) of the region of extinct volcanoes in Auvergne, France, showing fully the grand succession of changes which this region has undergone. (*b.*) A series of six relief maps of volcanic mountains and islands, colored geologically. They represent Mt. Vesuvius, Mt. Etna, Mt. Blanc, and the Islands of Teneriffe, Palma and Bourbon. (*c.*) A number of maps, views and charts of noted geological sites or phenomena, in various parts of the world, accompany the collection.

Besides the above relief maps, the collection possesses a splendid relief map (6 feet square) of the Grand Canon of the Colorado river, and the cliffs of Southern Utah, prepared from data obtained in the survey of the Rocky Mountain region under Major Powell. Also two relief maps of the Henry Mountains, three and a half feet by five, presented by the Hon. John Goode. The first of these shows the relief features of the country before erosion, and the second the present topography produced by erosion.

Division II.—Paleontology.

The specimens of fossil plants and animals are about 8,000 in number, and are equally distributed throughout the several geological formations. Each specimen is mounted on a block with a printed label, giving the generic and specific name, the geological horizon and the locality. The arrangement is a chronological one, the fossils of each great geological period being grouped together in zoölogical and botanical order.

The collection is rendered more complete by the addition of plaster models of rare and unique forms. These are copies in every case of the most perfectly preserved original specimens of the kind, existing in the museums of Europe and America.

SILURIAN PERIOD.

Among the fossils of this period are in the Museum eözoon, graptolites, corals, trilobites, cephalopods, &c., &c., with algae.

DEVONIAN PERIOD.

The vegetable kingdom is here represented by algae, acrogens and conifers. The animals by corals, crinoids, gasteropods, conchifers, fishes, reptiles, &c.

THE CARBONIFEROUS PERIOD.

The series of plants is large and striking, containing among the most prominent genera, lepidodendon, sigillaria, calamites, ferns, fruits of various kinds, &c., &c.

The animal remains include many forms of corals, crinoids, mollusks, fishes, and reptiles, &c., &c.

PERMIAN PERIOD.

This is represented by a few land plants, and by specimens illustrating the several sections of invertibrate life by many notable forms of fishes, and by some reptilian forms.

TRIAS PERIOD.

The plants are represented by voltzia, equisetum and pterophyllum. The crinoids are illustrated by several beau-

tiful specimens. The mollusks contain ceratites, ammonites, &c. The fishes and reptiles are well represented, and the ichnites of the Connecticut Valley are well shown in a large and fine suite.

JURASSIC PERIOD.

The plants are represented by noeggerathia and cycadoidea. The series of animal remains is large and interesting. From this we may mention the following: A great variety of sponges and corals, numerous forms of echinus, conchifers, gasteropods, belemnites, 125 species of ammonites of great variety, size and beauty. Several of them are over two feet in diameter; a number of polished sections of nautili and ammonites, showing the internal structure, &c.; insects beautifully preserved, fishes from the lithographic limestones of Bavaria, the lias of England, &c., showing numerous genera, several complete skeletons of ichthyosaurus and plesiosaurus, one of the latter twenty-two feet long (cast); head of ichthyosaurus, five feet long; a paddle of plesiosaurus over six feet in length, several skeletons of teleosaurus, pterodactylus, &c. These saurian forms are plaster casts. Restorations on a reduced scale of ichthyosaurus, plesiosaurus, megalosaurus and pterodactylus. Included with these are models of the cheirotherium of the Trias, and the ignanodon of the Wealden.

CRETACEOUS PERIOD.

The vegetable remains are leaves mainly, and belong to several modern genera, as the oak, sassafras, &c., &c.

All classes of testacea are well exhibited, but the collection is richest in sponges, echini, conchifers and cephalopods.

The typical genera, exogyra, gryphaea and inoceramus are well illustrated, as well as the peculiar groups of rudistes, hippurites, &c., &c. The most remarkable reptilian remains are heads of of crocodilus and mosasaurus.

TERTIARY PERIOD.

The plants are shown by a great variety of leaves, by silicified and bituminized wood, and by fruits. The invertebrates are headed by over 100 species of foraminifera, (enlarged models) and number over 600 species. They are chiefly gasteropod and lamellibranch shells. Of fishes there are many beautifully preserved entire specimens. There are shark's teeth from many localities. The reptiles are represented by crocodiles, frogs and tortoises. The restored carapace of colossochelys measures nine feet in length. Birds are indicated by the eggs.

The mammalian series is of great interest. A few of the more important forms only can be named. We have zeuglodon, halitherium (entire skeleton), mastodon, elephas, (skull and tusks of E. Ganesa), dinotherium (head and femur), paleotherium, rhinoceros, hipparion, equus, anchitherium, sus, oredon, hyaenodon, felis, driopithecus, sivatherium, &c., &c.

PLEISTOCENE PERIOD.

The plants are represented by forms similar to those now living. The invertebrates are well preserved and specifically identified with modern forms. The fish remains are chiefly shark's teeth. Birds are represented by dodo, epiornis (eggs) and palapteryx. The mammals approximate to living forms but are specifically distinct. The more noteworthy forms represented are mastodon (skulls, teeth and tusks), elephas (jaws and teeth), a complete restoration (life size) of the E. primigeneus or mammoth, giving all the characters of the animal, megaceros or Irish elk (entire skeleton), glyptodon, (carapace, tail, &c.,) cast of life size, machairodus, bos, bootherium, hippotamus, hyaena, castoroides, nototherium, diprotodon, megalonyx, mylodon, megatherium, (cast life size) sus, gulo, &c., casts of the Engis and Neanderthal skulls, and of the Guadaloupe skeleton, &c., &c.

Besides the above named specimens in mineralogy and geology, the collections which were previously in possession of the University are added to the Department of Geology and Natural History, and will aid in illustrating these subjects. There is, in addition, a large collection of the rocks and fossils of Virginia, made by Prof. Wm. B. Rogers, in his survey of the State, which is a valuable supplement to the collections of the Museum. It is proposed to add to this collection from year to year with the purpose of forming a complete illustrative assemblage of all physical resources and natural products of the State.

CABINET OF ZOOLOGY.

The Cabinet of Zoölogy contains about 12,000 specimens, and for convenience is divided into three series: I. Stuffed Vertebrates, II. Skeletons of Vertebrates, III. Invertebrates.

I. Stuffed Vertebrates.

Class 1.—*Mammalia.*—Under this class the following groups are represented by many specimens:

(1.) *Quadrumana*, containing simia satyrus, macacus cynocephalus, lemur, &c.

(2.) *Carnivora,* containing felis tigris (Bengal tiger), canis lupus (wolf), hyaena striata, ursus horribilis (grizzly bear), leo (lion), phoca vitulina (seal), and many others.

(3.) *Rodentia,* containing castor canadensis (beaver), cercolabes prehensilis (Brazilian porcupine), cricetus frumentarius, (hamster), sciurus bicolor (Java squirrel) myodus lemnur (lemming), hydrochoerus capybara (capybara), and many others.

(4.) *Edentata*, containing choloepus didactylus (two-toed sloth), dasypus peba (armadillo), and others.

(5.) *Ruminantia*, containing bos americanus (American bison or buffalo), camelopardalis giraffa (giraffe—young),

cervus canadensus (American elk), tragulus javanicus (Java musk deer), alces americanus (moose), ovis montana (Rocky Mountain sheep).

(6.) *Pachydermata*, containing asinus zebra (zebra) sus scrofa (wild boar), dicotyles torquatus (collared peccary).

(7.) *Cetacea*, containing phocaena communis (porpoise),

(8.) *Marsupialia*, containing macropus rufus (rufous kangaroo), phascolomys ursinus (wombat), phalangista vulpina (vulpine phalanger), echidna hystrix (echida), ornithorhynchus anatinus (duck mole), and others.

Class 2.—*Aves*.—(1.) *Raptores*, containing vultur cinerea (ashy vulture), aquila chrysaetus (golden eagle), strix otus (short-eared owl), &c.

(2.) *Insessores*, containing dacelo tyro (Australian kingfisher), crotophaga ani (Jamaica black bird), merops apiaster (bee-eater), upupa epops (hoopoe), corvus cornix (saddle-backed crow), paradisia apoda (bird of paradise), and many others.

(3.) *Scansores*, containing psittacus erythacus (gray parrot), rhamphastes picicourus (toucan), psittacidæ (parrots), and others.

(4.) *Rasores*, containing cupidonia cupido (pinnated grouse), columba livia (rock pigeon), gallus bankiva (jungle fowl), thaumalia picta (golden pheasant), perdix cinerea (European partridge), and many others.

(5.) *Cursores*, containing struthio camelus (ostrich), rhea Americana (American ostrich), otis tarda (great bustard), casuarius emeu (casso wary).

(6.) *Grallatores*, containi ng machetes pugnax (ruff), ardea cinerea (ashy heron), ibis religiosa (sacred ibis,) recurvirostra avocetta (avocet), fulica atra (coot), rallus aquaticus [rail], and others.

(7.) *Natatores*, containing phoenicopterus antiquorum (flamingo), anas clypeata (spoonbill duck,) oidema nigra (surf duck), aptenodytes chrysocoma (penguin), podiceps auritus (eared grebe), sula alba (gaunet), carbo cormorans

(cormorant), alca torda (razor-billed auk), and many others.

Class 3.—*Reptilia.*—(1.) *Chelonia*, containing testudo indica (Indian tortoise), emys tri-juga (three-keeled emys), eretmochelys imbricata (hawkbill turtle), ptychemys rugosa, (rugose terrapin), and others.

(2.) *Sauria*, containing alligator lucius (alligator), crocodilus, monitor niloticus (monitor), cyclodus gigas (scinck), lacerta ocellata (spotted lizard), and many others.

(3.) *Ophidia* containing python molurus (rock snake), boa (harlequin boa), and others.

(4.) *Batrachia*, containing bufo pantherina, salamandra maculosa (spotted newt), and others.

Class 4.—*Pisces.*—(1.) *Acanthopterygii*, containing chaetodon ciliaris, box vulgaris, dactylopterus volitans (flying fish), tinea vulgaris, and others.

(2.) *Malacopterygii*, containing balistes vetula (trigger fish), monocanthus (file fish), pleuronectes platessa (flounder), hippocampus brevirostris (sea-horse), cepola rubescens (red-ribbon fish), and many others.

(3.) *Chondropterygii*, containing malthea vespertilio (bat malthea), petromyzon marinus (sea lamprey), polyodon spatula (paddle fish), zygaena malleus (hammer-head shark), pristis antiquorum (saw-fish), and others.

The stuffed specimens mentioned in the preceding enumerative list are so chosen as to represent the entire series of natural orders in a full zoölogical classification.

Each specimen is mounted on a handsome ash pedestal, and is provided with a printed label, giving generic and specific name, author, locality, &c.

Alcoholic Specimens.—The serpents, batrachians and fishes are farther represented by a few specimens preserved in alcohol in sealed glass jars.

II. Skeletons of Vertebrates.

Class I.—*Mammalia.*—(1.) *Quadrumana*, containing troglodytes gorilla (gorilla), simia satyrus (orang), cerco-

pithecus sabæus (green monkey), cynocephalus mormon (mandrill baboon), and many others.

(2.) *Carnivora,* containing leo barbarus (lion), canis lupus (European wolf), mustela martes (sable,) lutea canadensis (otter,) taxidea americana (badger), ursus americanus (black bear), erinaceus europaeus (hedge hog), pteropus poliocephalus (roussette bat), and many others.

(3.) *Rodentia,* containing cricetus frumentarius (hamster), myodus lemnus (lemning), hystrix cristata (African porcupine), dasyprocta agouti (agouti), and others.

(4.) *Edentata,* containing bradypus tridactylus (three-toed sloth], tamandua tetradactyla (small ant-eater), &c.

(5.) *Ruminantia,* containing bos americanus (American bison), capra hircus (goat), antilocapra americana (prong-horned antilope), tragulus javanicus (Java deer), camelus bactrianus (bactrian camel) and others.

(6.) *Pachydermata,* containing equus caballus (horse), sus scrofa (wild boar), elephas indicus (Indian elephant), babirussa alfurus (babirussa—skull), and others.

(7.) *Cetacea,* containing phocaena communis (porpoise), halicore indicus (dugong), &c.

(8.) *Marsupialia,* containing halmaturus derbianus (kangaroo), phascolymys ursinus (wombat), echidna hystrix (echidna), and others.

Class II.—Aves.—(1.) *Raptores,* containing cathartes aura (turkey buzzard), halietus leucocephalus (bald eagle), bubo virginianus (great horned owl), and others.

(2.) *Insessores,* containing dacelo gigas (laughing jackass), luscinia philomela (nightingale), corvus americanus (crow), fringilla chloris (green finch), and others.

(3.) *Scansores,* containing chrysotis festivus (green parrot), picus viridus (green wood pecker), and others.

(4.) *Rasores,* containing pavo spiciferus (Siamese peacock), phasianus torquatus (collared pheasant), ectopistes migratorius (wild pigeon), and others.

(5.) *Cursores*, containing struthio camelus (ostrich), otis tarda (great bustard), and others.

(6.) *Grallatores*, containing strepsilas interpres (turnstone), grus canadensis (sand hill crane), tantalus loculator (wood ibis), fulica atra (coot), and many others.

(7.) *Natatores*, containing phoenicopterus antiquorum (flamingo), pterocyanea circea (summer teal), alca torda (razor billed auk), mormon arctica (puffin), larus fuscus (herring gull), pelecanus fuscus (brown pelican), and many others.

Class III.—Reptilia.—(1.) *Chelonia*, containing testudo graeca (European tortoise), ptychemys rugosa (rugose terrapin), platypeltis spinifer (leather turtle), chelonia mydas (green turtle), and others.

(2.) *Sauria*, containing alligator lucius (alligator), hydrosaurus marmoratus (monitor), pseudopus pallasii (scheltopusic) chameleo dilephis (chameleon), and others.

(3.) *Ophidia*, containing python tigrina (python), bascanion constrictor (black snake), pelamys bicolor (sea snake), and others.

(4.) *Batrachia*, containing rana mugiens (bull frog), pipa americana (surinam toad), salamandra maculosa (spotted newt), siren lacertina (siren,) and others.

Class IV.—Pisces.—(1.) *Acanthopterygii*, containing lucioperca americana (pike perch), dactylopterus votilans (flying gurnard), chætodon ciliaris (angel fish) temnodon saltator (blue fish), and others.

(2.) *Malacopterygii.*—Containing balistes vetula (trigger fish], cyprinus carpis [carp], ostracion cornutus [boxfish], amia occidentalis [dog-fish] lepidosteus bison [gar pike], and many others.

(3.) *Chondropterygii*, containing raia clavata (thornback ray), miliobatis aquila (eagle ray—jaws), squalus (shark), and others.

The skeletons enumerated in the preceding list are each mounted on a handsome black walnut pedestal, with

brass or bronzed standards, printed label, &c. They give together a full epitome of the science of comparative osteology.

III. Invertebrates.

The systematic zoölogical series represented as above enumerated, by the mounted skins and skeletons of the different orders of vertebrate animals, is continued and completed by a large cabinet of invertebrates. These consist of protozoa, sponges, gorgonia, corals, sea eggs, star fishes, shells crustaceans, insects, &c., &c. Most of these specimens are in a dry state, and are mounted on thin wooden or card-board tablets; a smaller portion is preserved in alcohol, in glass jars. The total number of species and varieties represented is fifteen hundred. The total number of specimens is over ten thousand.

Besides the above named collections belonging to the Cabinets of Mineralogy, Geology and Zoölogy, a considerable Cabinet of Botanical specimens has been procured for the Museum since the death of Mr. Brooks by the liberality of his heirs, who thus carried out to completion the design of the founder. This cabinet has been collected by Prof. Ward. Most of the specimens are on hand, but as they have not yet been arranged and mounted, nothing more can be said of them here.

On Some of the Relations and Teachings of Geology.

INAUGURAL LECTURE BY

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Any attempt to discuss in the limits a single lecture such a comprehensive subject as Natural History, or indeed any portion of it, however restricted, must be extremely imperfect and unsatisfactory. In the following remarks I can present only a few of the many facts which entitle Natural History to secure the earnest attention of an intelligent and educated public. The points which I shall touch upon are mere illustrations of the wealth of material which nature offers to the student of her phenomena. In order to deal with the subject with some degree of coherence, I shall confine myself to facts which ilustrate two points: I. The importance and usefulness of the knowledge imparted by Natural History; and II. The great interest of the problems with which it deals.

Nothing short of an elaboration of details would do justice to the importance and interest of these illustrative facts, but that would prolong this paper beyond all bounds. I must, therefore, content myself with little more than a mere enumeration of them.

The science of Geology is the most comprehensive of all the branches of Natural History. It makes use of all of them, and is indeed the study of all nature. It is hence

well suited to serve as the representative of Natural History. Regarding it as occupying this position, I shall select from its data the materials which may serve to exemplify the value and interest of the teachings of nature. We must first, however, fix the position and relations of Natural History.

Natural History, as it is generally limited, covers but a portion of the vast field of Natural Science. I use the word in its more comprehensive sense, not as a synonym of Zoölogy, but as including the three descriptive sciences, Botany, Zoölogy and Mineralogy, as well as the general science of Geology. Chemistry and Physics are branches of Natural Science, which are not included in Natural History. However, as these last two sciences furnish us with the general laws of nature, which find their expression and embodiment in the objects with which the branches of Natural History deal, it follows that the study of Natural History must embrace them also.

As Natural History is, in large part, an application of the general laws of nature, we find that until Chemistry and Physics had made such progress as to present a well digested body of laws, it could not exist as a science.

Any branch of Natural History which can claim the dignity of a Science must present us with the explanation of the origin of natural objects ; make known to us the conditions of their existence, as well as the nature and cause of their peculiarities. Without the use of chemical and physical laws, a would-be science of natural objects presents the character of peculiarities only as determined by morphological properties, such as color, shape, etc. When Chemistry and physics were in process of formation the branches of Natural History could be nothing but descriptive catalogues, since the basis of essential characteristics was wanting.

From this we see that there must be a certain order in the development of the departments of Natural Science—some must precede and some follow. This accounts for the

slow progress and late development of the branches of Natural History. Only of late have they made any rapid progress.

Now as Geology makes use of, and depends upon, all the departments of Natural Science, it follows that it must be the last in the order of development. This science, which in its broader sense may be defined to be, the physical history of the earth and its inhabitants, illustrates most beautifully the "unity" of Natural Science, and teaches better than any other the great fact that there are no sharply drawn lines of division between the departments of nature.

In our study of all the multitude of objects and phenomena with which it deals we learn that as our means of research improve the artificial barriers, erected by man to aid his limited intellect, are broken down. We learn from it the great plan of nature, and no more fitting motto could be erected over an assemblage of her products than the words: "Unity in endless diversity."

Let us, in the first place, consider some of the relations of Geology to the other branches of Natural Science.

The forces of Physics and Chemistry find now, and have found through long ages in and on the earth, a theatre of action on the grandest scale. Only by observation of the present changes of the earth and its belongings, can we study immediately such forces. Chemical and Physical theories are therefore Geological theories also, so closely are these sciences connected. It follows from this that the Chemistry and Physics of Geology are important integral parts of the science. So important a part, indeed, do chemical agencies play in the changes of the earth's component parts, that such authors as Bischoff, the great German writer on Chemical Geology, would explain all geological changes by the action of chemical forces, thus erecting a universal hypothesis on a chemical base. Inasmuch as minerals and their groupings form the rocks which constitute the mass of

the earth, it follows that Mineralogy, the science of minerals, is a most important part of Geology, and forms the starting point for the study of the composition and structure of the earth.

The composition of the earth has changed from time to time, minerals have been formed, removed and replaced by others. Hence Mineralogy gives the Geologist information concerning, not only the present, but also the past condition of the earth.

The inhabitants of the earth, the animals and plants, have not always been what they now are. Numerous forms have made their appearance, undergone changes, and passed away, to be succeeded by others of different character.

Now these changes in the life of the globe are records of changes in the earth, and of stages in her progress. As such the Geologist must study them, and to do so he must call to his aid the sciences of Zoölogy, Botany and Meteorology. He must know how changes in the surface features and climate of the earth can produce changes in living forms.

Botany and Zoölogy, applied to the explanation of extinct forms, constitute the department of *Paleontology*, a most important section of Geology.

Though this branch of the science does not admit of many practical applications, possessing immediate economic value, it is the most absorbingly interesting of all, as is shown by the numerous band of devoted followers who pursue it, at large cost, and with no hope of pecuniary return. Its surpassing interest is due to the grand problems of life and change, with which it deals.

Paleontology gives to Geology, not only important information concerning the past changes of the earth, but furnishes the means also of establishing fixed points in her career. She gives the data for dividing the column of sedimentary rocks into periods, marked by the peculiar life which prevailed on earth when they were forming.

The relations of Geology to Astronomy are closer than they might, at first sight, be supposed to be. Our globe must be studied, not only in its parts, but as a whole. Astronomy, in the modified nebular hypothesis of Laplace, offers the most probable theory of the genesis of the earth as a planet. She offers also plausible explanations of the former changes of temperature on the surface of the earth, those changes which gave rise to cold and warm periods.

To Astronomy too we must look for the origin of the *meteoric stones*, which perform the theoretically important part of adding to the original amount of matter in the earth. We must study also the Dynamics of nature in the earth, as it lies before us, in order to obtain light on past events in its history. For this purpose the aid of *Physical Geography* must be invoked. This science, as at present limited, is an ill-defined branch of Natural Science. It trenches upon the domain of Geology, Mineralogy, Zoölogy and Botany. It has properly for its object the study of the earth in its present condition, and should begin where Geology ends.

Having pointed out some of the relations of the several branches of Natural Science, we may now consider for a while a few of the important and useful applications which Geology allows.

The first point which may engage our attention is the great value of the study of Geology, in educating and expanding the mind, and in supplying it with food for thought. Dealing as it does, with nature immediately, and embracing the entire range of her operations and products, no study is so well fitted to employ, educate and develop all the powers of man. No study touches so many points in his mental and physical nature. Geology develops and trains, in an eminent degree, the powers of observation and discrimination.

It demands originality in the observer. He is bound by no fetters of authority, has to obey no rigid rules, which hinder free thought. He has no standards to conform to,

Taken in due measure, all these guides and controllers of unfledged thought are good, but may they not, are they not, too exclusively applied in the education of youth?

Do we, in our schedules for a liberal education, encourage sufficiently independence and originality of thought?

Do we train students to observe and use their observations?

The constant appeal to authority, the repeated application of rules, and a persistent comparison with standards of perfection, must develop unduly the tendency, already strong in the youthful nature, to lean on others, to follow example, and obey precept.

The study of a descriptive science, and especially of Geology, gives a young man training in just the habits of thought which make successful men—*i. e.*, habits of close observation, nice discrimination and skillful combination.

The study of books on Geology will not accomplish this. The student must examine nature in the field, the museum and the cabinet. Students of books have to use the material gathered by others. They may construct genetic theories, and thus perform a useful work, but they miss the inspiration of contact with nature, and can rarely feel the pure joy of adding to the sum of knowledge.

The scientific method, which is "to prove all things, and to hold fast to that which is good," is hostile to bigotry, surperstition and all forms of narrowmindedness. Where its true spirit governs, *isms* cannot flourish.

These are the weaknesses of the *non*-scientific mind. Let us take a single example for illustration. Belief in spiritualism prevails in many parts of our country, to an extent far beyond the conception of most persons. Minds of the highest order have fallen victims to its delusions.

This form of superstition, which has the impudence to claim to be a branch of Natural Science, denies, by its assumptions the basis of all Natural Science. Natural Sci-

ence has no foundation if the order of nature is not constant, but may be perpetually interfered with.

Of course no man, imbued with the true scientific spirit, can listen to such doctrines. I know that one or two men, honored in science, have given more or less countenance to some of the phases of spiritualism. In this they violate the first principles of science. Science cannot pretend to deal with any phenomena which may not be reduced to law. It should not dogmatically deny that such phenomena exist, but should declare that they lie outside of its province. The formation of universal hypotheses—*i. e.*, hypotheses which attempt to bring all related phenomena under one universal law, is a weakness of the *scientific* mind.

In the progress of the Science of Geology many universal hypotheses have been formed. At first such hypotheses give great impetus to the study of science, but they end by opposing its progress.

The true scientific spirit is opposed to such hypotheses. It aims to discover truth, no matter where it may lead. The upholder of hypothesis is too apt to neglect facts which oppose his belief, and to give undue weight to those which confirm it. Thus the true scientific spirit demands qualities of mind well nigh heroic, for few men can sacrifice pet theories with readiness.

We must not confound the discoveries of science with the hypotheses erected on them. Too many persons forget this distinction, and close their eyes to facts because the hypotheses to which they give rise are offensive to them.

Such are some of the advantages accruing to general intelligence and culture from the study of Geology. We may now examine some of the more special applications which can be made of the science to promote the material welfare of mankind.

A knowledge of Geology forms the basis of the Science of Agriculture. Lithology, one of the departments of Geology, teaches the structure and composition of rocks.

Chemical Geology teaches the mode of alteration of minerals and rocks, and the character of the products formed. All soils are formed by the disintegration and decomposition of rocks. No farmer need be told that the physical character and chemical composition of his soil are most important features in determining the amount and kind of crop which he can secure. All these points are learnt from Geology.

The topography, too, of the country influences greatly the agriculture of a district. The topography results directly from the structure, composition, mode of decay, and removal of rocks and soils. These are all geological data. The presence of springs, the flow of streams, the rain fall, and many other features which determine the agricultural character of a country, all depend upon the geological structure. Every practical farmer recognizes the differences in soils caused by geological differences, although he may do this only from the teachings of experience.

He knows that in this State the lands of the Tidewater region differ from those of the Piedmont district, and these again from those of the Great Valley or of the mountains. The Geologist will tell him that such differences are caused by the fact their soils are the products of rocks differing in composition, in structure, and in the topography resulting from their decay and erosion. Let us take an example to illustrate the difference between the knowledge of the man who farms by experience and that of the scientific farmer.

There are sandstones and shales in this State which contain no elements of fertility in their composition. Soils made by their decay look well and yield a return, so long as they contain fertilizing matter obtained from some other source than decaying rocks. They cannot be permanently improved, for by resting and lying fallow, they gain nothing from the decay of the rocks, the parents of the soil.

The non-scientific farmer could learn their true character only by a long source of cultivation. But the geological farmer might decide from an inspection of the rocks that he

could hope to find no elements of fertility in such lands, except such as he had added to them.

The development of the mineral resources of a country depends upon a knowledge of its geology. The valuable metals, minerals, and other products of mines and quarries, do not occur hap-hazard. Certain rocks and formations, as the Geologist knows, do not contain certain minerals, while others do. Again traces of minerals occur under circumstances where no large deposits can be obtained.

Besides the precious metals and minerals, the earth yields many other products of economic value, such as the mineral waters, brines, salt deposits, sands, potter's and fire clay, mineral manures, etc., all of which must look to Geology for their discovery, valuation and utilization.

But the value of geological knowledge does not depend alone upon the discovery of minerals. It is of no less importance to know when you cannot discover a given mineral, or when it cannot be found in paying quantities. Hundreds of thousands of dollars have been spent in the vain hope of making a valuable "find," where none such can be made. Minerals often occur in amounts just sufficient to lure the non-scientific on in the work of mining, when a knowledge of Geology would tell one that nothing of value can exist there.

In many cases the ignorant do not need the discovery of a mineral, or indeed any true indication of it, in order to persevere in their expenditure of money. They rely upon "signs," or upon some baseless tradition of a former discovery. It has often happened that such mineral-seekers have consulted Geologists concerning their prospects, and have been in vain dissuaded from further search. Especially is this the case when the explorer has in his employ one of the so-called practical miners and geologists. Men of this latter class, even when they know better, which is rarely the case, are generally the last persons to discourage the search for minerals. It flatters their vanity to be implicitly

relied upon by persons who in all things except the occult (?) science of minerals, possess far more information than themselves. Then too, it is hard to deliberately give up an enterprise which affords them employment. In this State there are not wanting cases of the kind alluded to.

It is astonishing how the search for valuable minerals fastens upon and dominates the minds of some men. In the case of the unscientific, this pursuit is a sort of gambling with fortune. I have seen men who had become almost, if not quite, monomaniacs on the subject, and who spent their lives in delving in out-of-the-way places, or in following up the traditions of hunters or Indians, who are reported to have found valuable deposits of metals. They even become superstitious as to the kinds of marks and signs which they must follow.

There is hardly a county in West Virginia, or in the mountain districts of this State, which has not its tradition, generally of some silver mine which cannot now be located. These prospecters do not always confine themselves to self-deception. Often by planting in particular localities specimens of value, obtained from known mines, they attempt to deceive others. This is not difficult to do, in the general absence of geological knowledge. Ignorance of Geology leads intelligent people sometimes to entertain absurd notions about the probable presence of mineral deposits. Some will assure you that a certain locality ought to contain iron, for the lightning strikes there. Rocky sterile hills and mountains, in the opinion of others, must possess minerals, especially if the inevitable Indian tradition appears.

A more general diffusion of geological knowledge would certainly, in all such cases, secure a more intelligent view of natural phenomena.

The mining engineer must of course be a good Geologist, for his work consists, in large measure, of the application of geological data to the winning of metals and minerals.

The civil engineer too, cannot afford to neglect this science. He, with the architect, must use cements, building stones, etc., in construction. Geology teaches the character of such materials and what agencies cause them to decay. Serious mistakes have been made from a neglect of the information which Geology gives. By its aid certain features in the composition and texture of building stones and roofing slates may be detected, which would render them worthless, though looking well to the inexperienced eye.

The civil engineer is called upon to select foundations for monuments, and for the piers and abutments of bridges. In such cases the knowledge of the geological features of the site is all important. In the case of the Washington monument, in the District of Columbia, a knowledge of the geology of the locality chosen would have much simplified the question of the sufficiency of the resisting power of its foundation. The civil engineer must calculate the cost of deep cuttings and tunnels through rocks. Without a knowledge of Geology he must depend largely in making his estimates on guessing. If his experience saves him from grave errors it does so because he has, by trial, acquired some knowledge of geological facts. The construction of the great tunnel through the Alps affords a striking illustration of the usefulness of geological knowledge in the profession of engineering. The Geologists had so carefully studied the structure of the Alps that they could furnish almost exact information regarding the character and amount of the several rocks through which the tunnel must pass. Then, again, the now mooted question of the possibility of tunneling under the English channel must be answered by the Geologists.

I might mention other special occupations and professions which would gain much from the aid of Geology. Indeed, there is almost no pursuit, which has for its object the promotion of man's material welfare, which does not, in some degree, depend upon geological data. But beside

these special applications to bread-winning pursuits, the influence of the geology of a country on the general character of a people, its political, social and commercial relations, is very great. Statesmen and political economists now-a-days more and more recognize the important influence on the general welfare of a country which is exerted by geological phenomena. Their knowledge, however, is empirical, and they do not trace the effects to their causes. From what has already been said, it will be seen that the topography and surface features of a country, the adaptation of its soils to the different agricultural pursuits, the presence or absence of mineral deposits, the course of rivers, etc., are all directly dependent upon the geology. Now all of these are most important agencies in moulding the character and controlling the relations of a people. We may perhaps best point out their influence by taking some examples where they have played an important part.

We learn from the study of the history of nations, taken in connection with the character of their country, the following facts. Uniformity in the surface of a country, ease of communication between its parts, with a variety of products and pursuits, promote a feeling of common nationality, secure independence, and thus form and maintain great nations. On the other hand, great diversity of surface and difficulty of communication, promote diversity of interests, and tend to form and maintain separate small nationalities. At the same time the mutual action of these small nations promotes industry and enterprise, and increases intelligence. Germany and Central Europe in general are striking illustration of the effects produced by geological structure. The structure of that portion of the Continent is such that numerous intersecting mountain chains are produced, which inclose isolated basins. This condition of the surface has tended to form and keep separate a number of petty nations, which are prevented only by the geological structure from forming one people. The task of

producing one empire out of these nationalities would have been far easier had the geology of the country been simpler. We would have had a great German empire long ago if the country were a plain or gently undulating land, penetrated by great navigable rivers. In any forecast of the stability of the empire now formed, we must take into account these features. Notwithstanding the strength of the common German sentiment and the overshadowing power of Prussia, we may safely conclude that a lasting homogeneous German empire is almost impossible.

In the United States we find an example of the opposite order of things. Here the geological character forbids the formation of numerous small distinct nationalities. The geological structure is such as to bind together the greater portion of the country. The principal mountain barriers are placed in the east and west sides, close to the Atlantic and Pacific oceans. This arrangement determines two long slopes, drained by numerous large rivers, which flow into a central lower portion occupied by the Mississippi river. The structure of the continent compels this river to empty into the Gulf of Mexico, which is an appendage of the Atlantic ocean. Thus the commercial relations of the great interior are the same with those of the Atlantic slope.

Only a comparatively small portion of the territory of the United States is isolated by its geological structure. The Pacific slope faces Asia, and its natural outlet is to that continent. Again the distribution of the material resources of the United States is such as to promote intercourse between the different parts, and to bind them firmly together. The geological structure has caused along the Atlantic slope, near and above the head of tide, an immense display of water-power. This fact, and the easy access to market, naturally cause the location here of great manufacturing and commercial cities. Most of our great Atlantic cities are placed just at the eastern margin of the crystalline rocks.

Farther to the west we find the useful minerals, coal, iron ore, etc., and forests yielding valuable timber in abundance. Still farther west the great grain and grazing districts are located. In the mountains, on the Pacific side of the Continent, we find the mines of the precious metals. All this results directly from the geological structure. Could there be a more favorable arrangement to bind the country together?

It would be an interesting problem to trace out what would be the effects of uniting the mountains in the centre of the Continent. Obviously the political result would be the existence of two great nations, differing in material resources, in commercial relations, and in other points so greatly that no force could hold them together.

If we ask why Equatorial Africa, so abounding in natural products, has remained till now closed to the civilized world, we find the answer in the geological structure of the country. This will, for a long time to come, compel it to remain isolated. Owing to the fact that the great rivers issuing from Central Africa have to pass over a high mountain border, they form rapids and cataracts.

Rivers easy to navigate attract commerce to a new country. If these do not exist, the interior must first be so far developed as to afford a variety of products sufficient to justify the erection of artificial channels of communication, such as canals, railroads, etc. This period, however, comes comparatively late in the history of a new country. Africa, owing to her geological structure, must first be developed from within.

It would not, at first sight, seem probable that Geology could give us any definite information concerning the material and social condition of pre-historic communities and nations, yet this is the case. The results of investigations in the caves, lake dwellings and refuse heaps of Europe are found to be most definite and valuable data for reconstructing the history of peoples who have left no other records of

themselves. Such materials are all the more valuable in history, as they are free from the distortion due to passion and prejudice.

In the winter of 1853–'54 the level of the water in Lake Zurich fell so low that attempts were made to reclaim the low lands along its shores by damming back the water. The excavations made for this purpose led to the discovery, in the mud of the lake, of various remains of former settlements, belonging to an unknown race, which inhabited that portion of Europe long before any that is recorded by tradition or history. It was found that for security they had built their dwellings over the lake on piles. In the accumulation made on the bottom of the lake, caused by the rejection of matter of all sorts, many articles are found so well preserved that an almost complete account of the habits and condition of the people can be made out. Implements of all sorts, weapons, bones of animals, grain, textile fabrics, and many other relics, throw a flood of light on the material, social, political, and even moral condition of ancient Europe. Since then similar remains have been found in numerous lakes in other parts of Switzerland, in Bavaria, Austria, Upper Italy, Mecklenburg and Pommerania.

The caves, peat bogs and shell heaps of many parts of Europe add their stores, so that now the study of these articles has become an important and extensive branch of Geology. I cannot pretend here to more than allude to these results. Such are some of the relations, applications and uses of the Science of Geology. It is a singular truth that, notwithstanding the fact that the earth is our home, and thus might be supposed to be of the highest interest to all men, but few seem to be interested in its history. Geology must long remain the special study of the select few.

I cannot leave this part of my subject without calling special attention to the great importance of establishing surveys to make known the geology of a country. Geolo-

gical surveys are the starting points in the development of the physical resources of a State.

A geological survey would be especially valuable to Virginia. She claims to possess great physical resources, and yet, although she is the oldest of the States, she has done almost nothing to make these resources known. Virginia now is less known to the scientific world than the youngest Territory of the United States.

Foreigners no longer invest their capital without depending largely on science to give them accurate information. Even the greatness of the claims of this State, to the possession of valuable undeveloped wealth, is against her, so long as these claims are vaguely stated. Anything that is written about Virginia is sought for and eagerly read, provided it has the authority of the State or of some one known in science.

I have been told that a complete copy of the reports of Prof. Wm. B. Rogers would command its weight in gold. It cannot be obtained. And here I would do violence to my sense of justice if I did not pay a tribute to the value of the scientific work of this eminent gentleman.

Called by the Legislature of Virginia, more than forty years ago, to devote the time not occupied by the duties of his chair in this Institution to the survey of the State, he performed this duty thoroughly, so far as the time and means at his command allowed. The results which he obtained amount to a complete preliminary survey of the State, with, in many cases, a large amount of detail work. They have never been published in any complete form, and are as yet lost to the State and to science.

It must be remembered that when Professor Rogers made his examinations Geology was in its infancy. The geology of the United States was then being worked out, and was mainly unknown. When we take these facts into account, along with the shortness of the time allowed him, and the scanty and imperfect scientific apparatus possessed,

the amount and accuracy of the work done by him is marvellous. I have have had occasion to go over many parts of the ground formerly investigated by him, and I have constantly had reason to admire the accuracy of his work. Some of his conclusions, where he was not able to fully work out the geology, viewed in the light of late discoveries, seem to be veritable intuitions, so amply have they been justified.

It remains now to examine briefly the nature of the problems with which Geology deals. It will be best for this purpose to select for illustration some one of the many that present themselves, and see what Geology teaches concerning it. The history of the plant life of the globe is well suited to show the geological method of dealing with the many questions that engage the attention of the Paleontologist.

The surface features of the earth, immediately after the formation of a solid crust, were, no doubt, far simpler than they are at present. No high lands or mountains existed. Water covered nearly the whole surface. There were no zones of climate, and the first forms of vegetation were consequently of the simplest kind, and nearly the same plants were found everywhere, even near the poles. These vegetable forms were not land, but marine plants, or sea weeds.

As contraction of the crust of the earth took place, from the continued loss of heat, elevations and depressions of the land occurred. The seas deepened and narrowed, and the lands grew higher and more extensive. The action of the atmosphere and of moving waters wore down some portions and built up others, covered the surface of the earth with layer after layer of sedimentary rocks, and thus increased the complexity of the earth. By this means an ever increasing variety of forces was brought to bear on the plant life. Owing to these causes great changes took place in the vegetation covering the surface of the earth. Entire classes of plants became extinct, and were succeeded by

others, so that the character of the vegetation changed many times. These changes were always in the direction of higher organization, greater diversity of species, and a more strict limitation in habitat. The record of such changes we find in the fossil plants contained in the sedimentary rocks. We do not know that any portion of the crust of the earth, first formed after cooling, is now visible. The oldest known rocks, the Laurentian, are certainly sediments deposited in water.

We may divide the column of sedimentary rocks into five grand divisions. They are as follows, beginning with the oldest: I. The Protozoic, containing the Laurentian, Cambrian and Silurian ages. II. The Paleozoic, containing the Devonian, Carboniferous and Permian. III. The Mesozoic, containing the Triassic, Jurassic and Cretaceous. IV. The Tertiary, containing Eocene, Miocene and Pliocene. V. The Modern, containing the Quarternary and Recent. Each of these is marked by a vegetation peculiar to it. The oldest sedimentary rocks of the globe, the Laurentian, including the Huronian, are not known to have contained plants. These rocks are too much altered to exhibit them in recognizable form. They contain, however, large amounts of carbon, in the form of graphite or plumbago. A portion of this, no doubt, originated in vegetation. In this State we have examples of such graphitic rocks in a belt of country running parallel, to and east of the Blue Ridge. The vegetation, if it existed, must have been sea weeds. The same may be said of the Cambrian vegetation. This latter formation exhibits certain fossils which are commonly classed with the sea weeds, although this classification does not rest on very certain data. The oldest certainly known plants are certainly sea weeds from the lower Silurian. These are so varied and general in type that their affinities cannot be clearly made out. There is hardly any differentiation of parts in them, and nothing like organs is shown. So far as we know, the land in the lower Silurian had not

increased sufficiently in amount and diversity of feature to permit the appearance of land plants, for none, as yet, have been found. It is very probable, however, that they did exist, for they make their appearance in the next succeeding formation, the lower part of the middle Silurian with forms of pretty high type, the ferns.

A great interval separates land plants from sea weeds. The uniform conditions which prevail in the waters of the sea do not call for that complexity of form in sea weeds which would be required to endure and withstand the various forces which act on the inhabitants of the land. Hence we find that land plants are more complex and highly organized than sea weeds.

When the waters were drained off some sea weeds might survive in bogs and marshes, and if they could accommodate themselves to their changed circumstances, perhaps they might endure for long periods with a changed character. Still we know nothing of the forms or manner of appearance of the first land plants. The oldest known land plants come from the middle Silurian of Europe, and are represented by a fern, the Eopteris Morieri, a plant of pretty high type.

It is a singular fact that the family of ferns, though the oldest known land form, is still abundant both in species and individuals.

Many types of the older land vegetation, which were introduced long after them, have entirely passed away. This oldest fern does not differ greatly from the modern ones, though the genus and species do not now exist. This fact certainly shows an extraordinary persistence in the fern type, and adds greatly to the interest of this remarkable group of plants. Land plants belonging to several distinct types have been found in the upper part of the lower Silurian of Ohio. This horizon in the American column is perhaps but little higher than the habitat of the Eopteris above mentioned, and thus land plants make their appear-

ance in Europe and America at nearly the same time. The Ohio plants belong to types which are not distinctly defined, and are unlike anything now existing. Some of these are forms which become very abundant in the succeeding Devonian and Carboniferous ages. They well illustrate the great truth that most of the earliest plants are generalized forms, containing in one individual, characters which become later widely separated, distinguishing genera and species. Their mode of appearance also shows another important fact, which characterizes the first appearance of the different plants in all geological ages, viz : that new forms arise at first, with but few species and individuals, and often in the era which precedes that in which their greatest development will be found.

In the next age, the Devonian, the vegetation has gained in amount, diversity, and grade of organization. The forms which had sparingly appeared in the Silurian, such as annularia, sphenophyllum, ferns, &c., now become abundant. Other and higher plants are added. Reed-like plants, the calamites, allied to the scouring rush of the present day, and coniferous trees make their first appearance. The curious compound type of Lepidodendron, allied to the club-moss of the present time, and so characteristic of the lower carboniferous, also occurs for the first time. The vegetation of the Devonian is essentially the same with that of the next, or Carboniferous age, but is not so abundant, diversified and specialized. In the coniferous trees of the Devonian we have the first indications, from the vegetation, of the existence of high lands. Still, nearly all the vegetation was adapted to growth in low lands and marshes. The presence of tree ferns shows that already the fern family had, in some of its forms, reached its highest point of organization, though as yet but in rare cases. In the Carboniferous age the peculiar type of vegetation which is characteristic of the Protozoic time, reached its culmination in vigor of growth and number of species and individuals.

The ferns are now greatly multiplied, and towards the close of the age many become arborescent. The types of Lepidodendron, Sigillaria and Calamites, reach their culmination here, then decline and perish in the next period, the Permian. The same may be said of a vast number of other forms. Tne gymnosperms became multiplied in genera and species. Forms appear allied to the true conifers, now so abundant on the earth. The vegetation was so luxuriant that its remains furnish us with most of the coal we now use. The Permian period is properly the close of the Carboniferous age, when most of the Protozoic vegetation perished, and where some of the forms destined to abound in the next following Mesozoic time, first make their appearance. Every fact indicates that in the Protozoic time the water predominated over the land much more than at present. The surface features of the earth were much simpler, the land was lower, being largely composed of bogs and marshes. There were no zones of climate, and the same vegetation flourished everywhere. It indicates that the climate was warm and moist, and that the air was heavily charged with vapor of water and with carbonic acid. There was no bright sunshine, and hence no flowering plants existed, and no trees with organs and foliage like our modern forest growths. The vegetation consequently had a monotonous and gloomy aspect in keeping with the rest of nature. Most of the plants were of compound character and of comparatively low grade.

The extensive destruction of plant life in the Permian was caused by the great changes which took place then on the earth's surface. These lifted up and laid dry great areas of land, and unfitted it for the growth of the Protozoic vegetation. The sun too now began to make its influence more powerfully felt, to the detriment of shade-loving plants. We have an example of these great movements of the earth in the United States, for the great Appalachian upheaval, which formed the Alleghany mountains, and

raised the Appalachian coal field high in the air, took place in the Permian.

The greater expanse of land, its greater diversity of altitude, the brighter sun and purer air made themselves felt in the vegetation of the next following Mesozoic time, and go on increasing in effect all through it. In accordance with the general law, some of the Mesozoic plants made their first appearance in the Permian. Among them we find coniferous trees, preferring hilly grounds, like the modern pines, and sun-loving plants, such as the cycads and zamias, many forms of which still live in tropical and sub-tropical lands. The peculiar type of conifer, now represented by the single species, gingko or salisburia, made its first appearance in the last stages of the Carboniferous age. The Permo-Carboniferous beds of West Virginia yield a form so close to the modern salisburia that Count Saporta affirms that it is a true salisburia. The cycads, zamias and gingkos are greatly developed in the Mesozoic, attaining their culmination about the middle of the time. They are compound types, and with ferns, conifers and the equisitae, make up almost entirely the vegetation of this time. The equisitae are not essentially different from the living ones, and with some of the ferns establish a closer relation with the present vegetation. There is in the vegetation of the Mesozoic a marked progression towards modern characters. But still, when compared with our present plants, it is more generalized and of lower grade. The types of plants which characterize the Mesozoic reach their culmination in the middle Mesozoic, and end in the lower Cretaceous. Here we find a change of great significance taking place. In the lower Cretaceous occur, so far as is yet positively known, the first angiospermous plants—*i. e.*, forms similar to our modern flowering plants and forest growths. This type of vegetation, having true flowers and seed vessels, now predominates by far on the earth. But in the lower Cretaceous there is, as yet, only a single species

known, a poplar, which is hence the oldest of our arborescent genera. In this formation the Mesozoic type still predominated. Its flora consisted of ferns, cycads, conifers and a few equisetæ.

In the middle Cretaceous we find the predominant vegetation to be angiospermous, not differing very greatly from modern forms. The Mesozoic vegetation, which like the Protozoic, had prevailed all over the earth, even as far towards the poles as man has penetrated, no longer is found in the extreme north. It begins to retreat towards the equatorial regions. Heer has found in Greenland a lower Cretaceous formation, with an abundant Mesozoic flora, and over it upper Cretaceous beds filled with modern forms of plants. Here the middle Cretaceous is wanting. In the Dakota group, which is extensively displayed in our Territories, on about our latitude, we find an abundant flora closely resembling our present forest trees. This group corresponds to the middle Cretaceous of Europe.

We thus find in the middle Cretaceous clear indications of the commencement of the formation of zones of temperature, and along with this of the introduction of the modern forms of plants. The question arises what was the origin of the first angiosperms, a type of plants so different from all which preceded.

Clearly their appearance was connected with the increasing refrigeration of some parts of the earth. The first forms we perhaps have not seen, for the oldest known to us do not differ greatly from those now living.

The close of the lower Cretaceous was then the most important era in the history of plant life. It marks a great change from ancient to modern conditions, a change which is nowhere else equaled in extent. There has since been no essential modification of the vegetation then introduced.

The changes since have been principally in the direction of increasing the variety of forms and a stricter limita-

tion of them to particular parts of the earth. We have in Virginia two series of beds which contain vegetation of the Mesozoic type. The older of these floras is contained in the Richmond coal field. The plants are quite numerous and plainly indicate that the age of the beds is Rhaetic or lower Lias, the period succeeding the Trias, the oldest of the Mesozoic eras. The younger flora is found in the beds at Fredericksburg, and appears to be a little older than that of the lower Cretaceous. Many most interesting plants occur here, and promise to throw much light upon the vegetation of that ancient period. It is mainly tropical in type, and seems to contain several well marked angiospermous plants. If this proves to be the case our Fredericksburg beds will contain the oldest known plants of this most important modern type. Most Geologists regard all these Mesozoic beds in Virginia as Triassic, but do so erroneously, and notwithstanding the correct interpretation of them made long ago by Professor Rogers. The appearance of angiosperms in America sooner than in Europe is in accordance with the general law that has been established, which is, that the vegetation of the American formations is older than that of the European. In the Dakota beds of the western part of the United States, which correspond with the middle Cretaceous of Europe, many of the most interesting genera of trees and shrubs, which now abound in our forests, made their first appearance. Since this ancient period, strange to say, these plants have undergone but little modification in type, though many of them are greatly reduced in the number of their species. Many of them also show evident indications that they are about to pass away. It is a singular fact that, although in other parts of the world the plant life has changed many times since this Cretaceous period, we still find in eastern North America, and in eastern Asia, forms which are contained nowhere else, and which are but little changed from their Cretaceous prototypes. Owing to the survival of a remnant of this

ancient flora on the Atlantic side of the United States, and in China and Japan we find many of the plants of these widely separated countries to be almost identical. The following are some of the most noteworthy forms of this Cretaceous flora which still survive:

The genus poplar, represented by the aspen and cottonwoods of the present day, has, as was stated above, the distinction of being the oldest known angiosperm, for it made its appearance in the lower Cretaceous of Greenland. It still persists with many species, and shows no signs of decadence.

The genus liquidambar, or sweet gum, made its first appearance in the middle Cretaceous of the Dakota group. It is now found on the Atlantic slope, represented by only one species, our common sweet gum, or liquidambar styraciflua, and in eastern Asia by one almost identical species, L. orientalis. Both surviving species differ in nothing essential from their Cretaceous ancestry. The poverty in species and strict limitation in habitat of the genus, show plainly that it has long since passed its culminating point.

The genus platanus, the sycamore or button-wood, began in the middle Cretaceous. It is represented now in eastern North America by only one species, the P. occidentalis, and in eastern Asia by one P. orientalis. This genus too is evidently declining. Our species, the noble sycamore, is strictly limited in area and locality, while the old trees soon become seriously diseased.

The genus sassafras began in the middle Cretaceous, and now survives in only one species, which is confined to eastern North America. It is peculiarly an American plant, and has not changed in any important point since its first appearance. It ranges over a wide extent of country, and is remarkable for its vigor of growth and prolific character. In Virginia certainly it does not seem to be in process of extinction.

The two magnificent allied genera, liriodendron, or tulip tree, and magnolia, are the most noteworthy of all the trees which had their origin in the middle Cretaceous. These two genera also are peculiarly American. They are restricted to the eastern part of the United States, with the exception of perhaps one species of magnolia in Mexico.

They are distinguished by their ancient lineage, the size and beauty of their flowers, their vigorous growth, their limitation in species and their restricted habitat. The true magnolia, containing eight species, is the more widely diffused genus, and is no doubt destined to endure longer than the liriodendron. As represented by the magnolia grandiflora of the Southern States, this genus, without doubt, furnishes the queen of our forests.

The liriodendron, or tulip tree, improperly called sometimes poplar, is by far the most interesting of our trees. The only living species is the splendid tree which is the ornament to our forests. It is confined to a belt of country lying between New England and Florida, and extending from the Atlantic to Michigan and Illinois. It reaches its perfection in about our latitude. From the value of its timber and the size and beauty of its trunk, it may be fairly called the king of our forests. Everything indicates that it is not destined long to survive the struggle for existence.

Among the other still surviving plants of the Cretaceous flora, now found on the Atlantic slope of America, we may mention the persimmon, oak, willow, beech, birch, ivy, buckthorn, walnut, hackberry and moonseed. All of these differ but little from their Cretaceous ancestors.

Professor Lesquereux has given in Vol. VI of the "Reports on the Geology of the Territories," a good description of the flora of the Dakota group, and to it I am indebted for many of the above details.

In the upper Cretaceous of Greenland we find mainly the same types of plants as in the Dakota group. The great variety and luxuriance of this vegetation in such high

latitudes suggests a question which has not yet received an answer. These plants required not only far more heat than is now found in polar regions, but they could not survive the present long periods of darkness which recur every winter. We might, without going counter to the truths of Geology, account for the needed amount of heat. A sufficient amount of sunlight, however, cannot be supposed to have existed, unless the axis of the earth has been changed, and such a change is not shown by Astronomy. Principal Dawson suggests that heat alone might suffice to preserve, during the arctic night, plants like those of the Cretaceous. He mentions the fact that Europeans in Greenland can preserve hot-house plants by keeping the temperature up to the proper point. But the people in high northern latitudes use much light-giving fuel, and we do not know how far the artificial can supply the place of natural light. Besides we do not know how long hot-house plants may be thus preserved, and we cannot compare their growth with that of plants depending on free nature.

The vegetation of the Tertiary and Quartenary continued to approach in type and distribution that of the present time. The careful study of the fossil flora of Europe throws a great deal of light upon the history of the plant life of the globe during this period. In Europe the entire character of the vegetation changed several times, and each change brought it nearer to its present character. We find that the formation of zones of climate first indicated in the Cretaceous, continued throughout this later period. The cold of the polar regions increased, and drove towards the equator first all tropical plants, then those requiring a temperate climate, and lastly everything except the scanty arctic vegetation which we now find there. During the same period all the now existing forms gradually took shape and adjusted themselves to the conditions existing at this time.

We learn from this study of extinct plants that the veg-

etation of the globe is far from being at any time fixed, and that in the future still other changes must occur, which no one can now predict.